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Hasta Velitaris
The first edge of the Roman army

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The authors of most studies dealing with the tactics and armament of the Roman army during the supremacy of the Middle Republic focus mostly on heavy infantry, which formed the core of Rome's armed forces.[1] Other available works deal with the subject of cavalry. Compared to these two, the *velites*, i.e. lightly-equipped troops which were indispensable for successful employment of heavy infantry, receive significantly less attention. This is reason enough to attempt to reconstruct the basic piece of weaponry of these javelin-throwing units, called *hasta velitaris*[2], and study its capabilities and limitations.

Javelins of the *velites*

The most detailed description of the weapon used by Roman light infantry[3] was provided by Polybios. Book six[4] of his work contains a lot of valuable information regarding the weapon, which combined with the archaeological and iconographic sources makes it possible to try and reconstruct this type of javelin. Based on the description of the Greek historian, the javelin shafts of the *velites* (*grosphōn belos*) were around two cubits long (*dipēkhu* – approx. 90 cm)[5] and two "fingers" wide (*daktuliaion* – approx. 18.5 mm). The iron head, with the length of one "hand" (*spithamiaion* – approx. 22 cm) was forged and sharpened to a point so fine, that it would bend on impact, which prevented the enemy from reusing the projectile – this must have been common practice[6].

A similar, although not as detailed description of the weapon can be found in the work of Livius, which mentions a group of elite soldiers equipped with seven javelins, 4 feet (approx. 120 cm) long, with an iron head, reminiscent of those used by *velites*[7]. Unfortunately, we do not know if the specified length of the weapon includes the head or not. Appianos, on the other hand, mentions that the light infantry fighting in the battle of Zama, held weapons repared specially to counter the attacks led by elephants[8].

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[1] P. Connolly, *Pilum, Gladius and Pugio in the Late Republic*, "Journal of Roman Military Equipment Studies", 8, 1997, p. 41-57; L. Rawlings *Army and Battle During the Conquest of Italy (350-264BC)*, [in:] R. Erdkamp, (ed.), *A Companion to the Roman Army*, Oxford 2077, p. 55-58; A. Zhmodikov, *Roman Republican Heavy Infantryman in Battle (IV- II Centuries B.C.)*, "Historia. Zeitschrift für Alte Geschichte", 49, 1, 2000, p. 67-78.

[2] *Hasta velitaris* – a term used by Livius (Liv., 26.4.4, 38.20) and other authors (Cic., *Brut*., 78.27) to refer to the javelins used by the *velites*. On its own, "*hasta*" usually means "spear", but in this particular case we may be certain that the intended meaning is "javelin".

[3] Polybios refers to Roman light infantry as *grosphomakhoi, akontistai* or *pezakontistai*. These names most likely have the same meaning as the term *velites* used by Livius.

[4] Plb., 6.22,10; Liv., 28.14.17-20.

[5] We cannot be certain about the measurements used by Polybios, which is why only approximate values are given.

[6] Caes., *Gal.*, Sall., *Jug*., 58.3; Liv., 38.22.6 – these examples of sources are intended to illustrate general tendencies to reuse any weapons captured from enemies and to recover own weapons from the battlefield.

[7] Liv., 26.4.4.

[8] App., *Pun.*, 7.41.3.

The shafts were 2 cubits long and the weapon featured a long iron head. Appianos also states that a large part of the javelin was iron-shod, which may simply be a mistake due to his unfamiliarity with the weapon, or a poor choice of words resulting from misunderstanding of the source that he had based his description on[9]. Most probably, what Appianos described was in fact the standard-issue equipment of Roman light infantry.

Because of the way they fought, javelin-throwers probably did not carry many projectiles to battle. The number of javelins given by Livius seems rather high, and most likely refers to soldiers who were in the march or preparing to the battle. It is not clear if *velites* used any quivers or additional projectiles during actual engagements – like the one on the bas-relief from the 3rd century CE depicting the legionary Aurelius Mucianus. But even if such pieces of equipment were in use, they would rather serve as a means of transporting excess javelins. In combat, similar containers would restrict movement, thus limiting the overall combat effectiveness of individual soldiers. It is likely that spare projectiles were left stored at the positions occupied by the main forces and could be picked up while regrouping for use in consecutive engagements – as there would be more than one in the course of the whole battle[10].
A light infantryman would presumably carry between three and five javelins into combat[11]. There is a logical explanation for this, as the average human can (relatively comfortably) hold only up to four javelins with a thickness of approx. 20 mm in their left hand, while simultaneously holding the shield grip. It does not seem probable that spare projectiles would be stored on the battlefield close to the fighters, due to the dynamic character of infantry engagements and the high probability of losing these weapons if one side was driven back from their positions.

Unfortunately, there are no iconographic sources depicting the *velites* specifically, but other images of Roman fighting men and their equipment do include javelins constructed according to Polybios's description. One of the most valuable ones is the fresco adorning the walls of a tomb in Capua[12](fig. 1), which shows a duel between two warriors. Another is an Etruscan tomb from Tarquinia, dated to the 4th century BC (fig. 2), where we find depictions of a substantial collection of military equipment, which includes three javelins with heads similar to that of the *hasta velitaris.*

The above descriptions and images of such non-typical javelin heads were corroborated by archaeological materials. The oldest finds of the iron heads in question that occur in an unequivocally

[9] Perhaps in this case Appianos based his description on the account by Livius (Liv., 26.4.4).
[10] Plb., 11.22.9.
[11] Nicholas Sekunda suggests a similar number of javelins based on the account by Lucilius, N. Sekunda, *Republican Roman Army 200-104 BC*, London 1996. But in this case, due to the fact that the text is incomplete, we cannot determine with any certainty if the javelins in question belong to the equipment of light infantry. Perhaps they are mentioned as rewards for heroic feats on the field of battle – this seems more probable based on the reading of preserved fragments (Lucil., 7.323).
[12] The javelin in question is probably held by the figure on the right. The fresco was most likely destroyed during World War II – A. Small, *The Use of Javelins in Central and South Italy in the fourth century BC*, [in:] D. Ridgway, F. R. Serra Ridgway, M. Pearce, E. Herring, R. Whitehouse, J. Wilkins (ed.), *Ancient Italy in its Mediterranean Setting: studies in honour of Ellen Macnamara,* vol. 4, London 2000, p. 227.

Roman context are from Šmihel in Slovenia, where a large number of weapons was found in the years 1890-92. The pieces are dated approximately to the year 175 BC[13]. One noteworthy aspect is the small

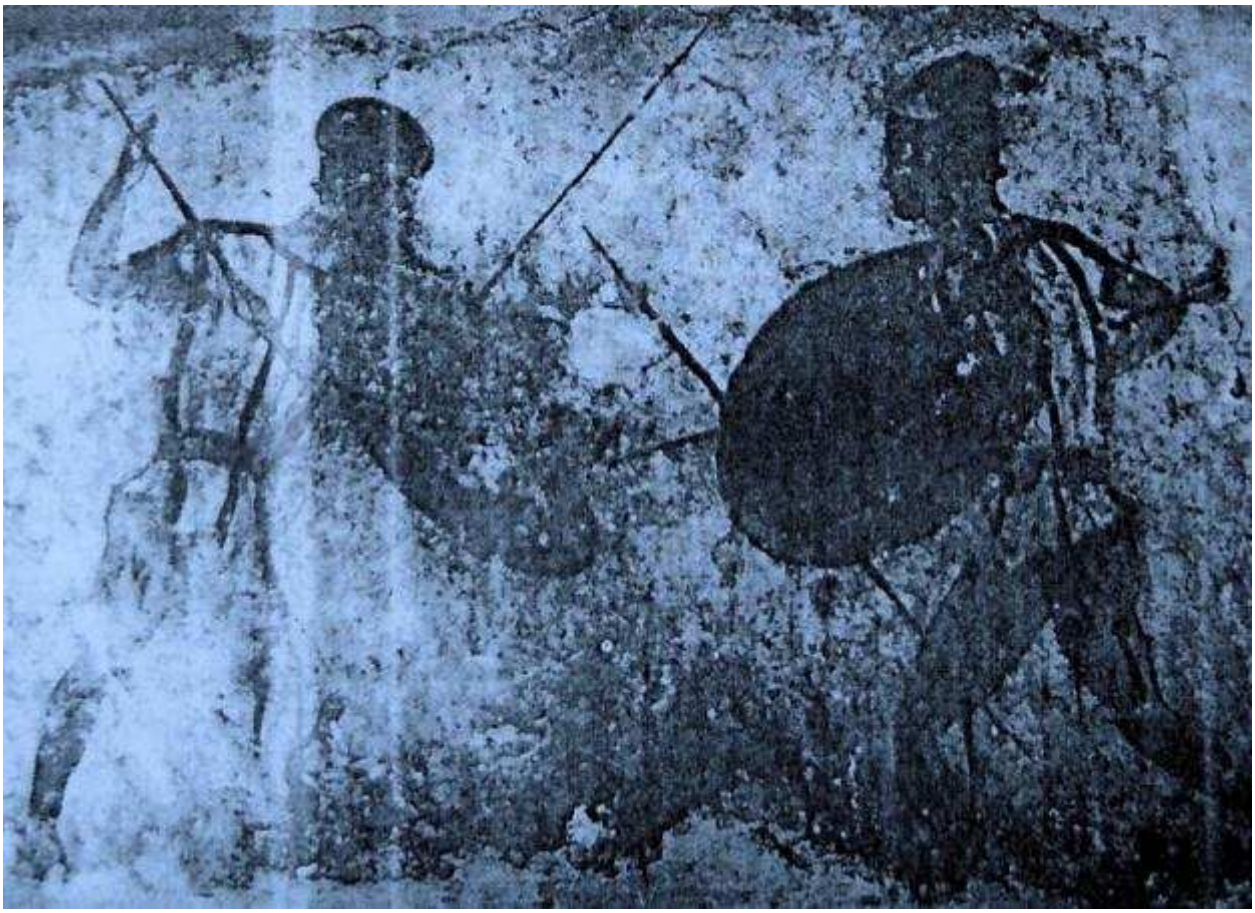

Fig.1. The fresco in a tomb in Capua.

Source: A. Small, *The Use of Javelins in Central and South Italy in the fourth century BC*, [in:] D. Ridgway, F. R. Serra Ridgway, M. Pearce, E. Herring, R. Whitehouse, J. Wilkins (ed.), *Ancient Italy in its Mediterranean Setting: studies in honour of Ellen Macnamara,* vol. 4, London 2000, p. 227.

[13] J. Horvat, *The Hoard of Roman Republican Weapons from Grad near Šmihel*, "Arheoloski Vestnik" (Arh. Vest.), 53, 2002, p. 117-192 (Connolly – 175 BC +/- 10 years, Connolly, *Pilum, Gladius…*, p. 47-57; Bishop, Coulston – 175 BC – M. C. Bishop, J. C. N. Coulston, *Roman Military Equipment: From the Punic Wars to the Fall Of Rome*, Oxford 2006, p. 51 -53).

Fig.2. Painting from an Etruscan tomb from Tarquinia.
Source: P. Connolly, Grees And Rome At War, London 2006, p. 100

difference in years between the dating of this find and the date of Polybios's stay in Italy, i.e. 167 CE. This fact makes his description of these specific javelins all the more valuable.

Among the Šmihel hoard there is a significant number of javelin heads, which in the opinion of certain scholars[14] belong to the equipment of *velites*. This seems a correct interpretation. They were forged in the shape of a long and narrow rectangular rod tapered to a point on one end and on the other end equipped with a sleeve used to mount the head on the javelin shaft; it was then fixed in place by a nail hammered into an opening at the base of the sleeve. The sleeve diameter was no more than 19 mm, and oftentimes around 16-17 mm[15](fig. 3). Most of the javelin heads from this hoard are longer than the ones described by Polybios. But we should bear in mind that the heads of both light and heavy javelins utilized by the heavy infantry also vary significantly in length as well as design, which indicates that there was no fixed standard in this regard. Polybios himself would most likely be aware of these differences; nevertheless, when talking about heavy infantry javelins he still gives specific dimensions[16]. This was probably done in an attempt to simplify the narrative. A few weapon heads from later periods, similar in size and design, were also found in Ephyra, Renieblas, Numancia, Caceres el Viejo, Alesia or Osuna[17], but some examples have a pyramid-shaped barb at the tip, reminiscent of the heavy *pila*. These are the two most common types of javelin heads used by light infantry units, with the exception of classic leaf-shaped ones.

It is difficult to determine if Romans preferred specific kinds of trees or bushes for their javelin shafts. Most probably all kinds of timber were used for military purposes due to the fact that during a campaign soldiers would be forced to use local species to repair any damaged or worn-out weapons if they could not expect to receive resupplies. Out of the few available accounts regarding various armies of the antiquity we know that, if available, harder and heavier kinds of timber were preferred. Dogwood and ash seem to have been the dominant kinds used for manufacture of javelins and spears[18]. Combining high resistance and flexibility, they were ideal for these weapon types.

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[14] Horvat, op. cit., p.138; Connolly, *Pilum, Gladius*..., p. 44.
[15] Data based on figures found in: Horvat, op. cit., p. 138.
[16] Plb., 6.22.4.
[17] Bishop, Coulston, op. cit., p. 51-53; Connolly, *Pilum, Gladius*..., p. 44.
[18] Grat., Falisc., *Cyneg*., 128-137. Cynegeticon (the author lists the kinds of trees especially suitable for the manufacture of spears and javelins, with dogwood and yew being among the highest-ranked ones).

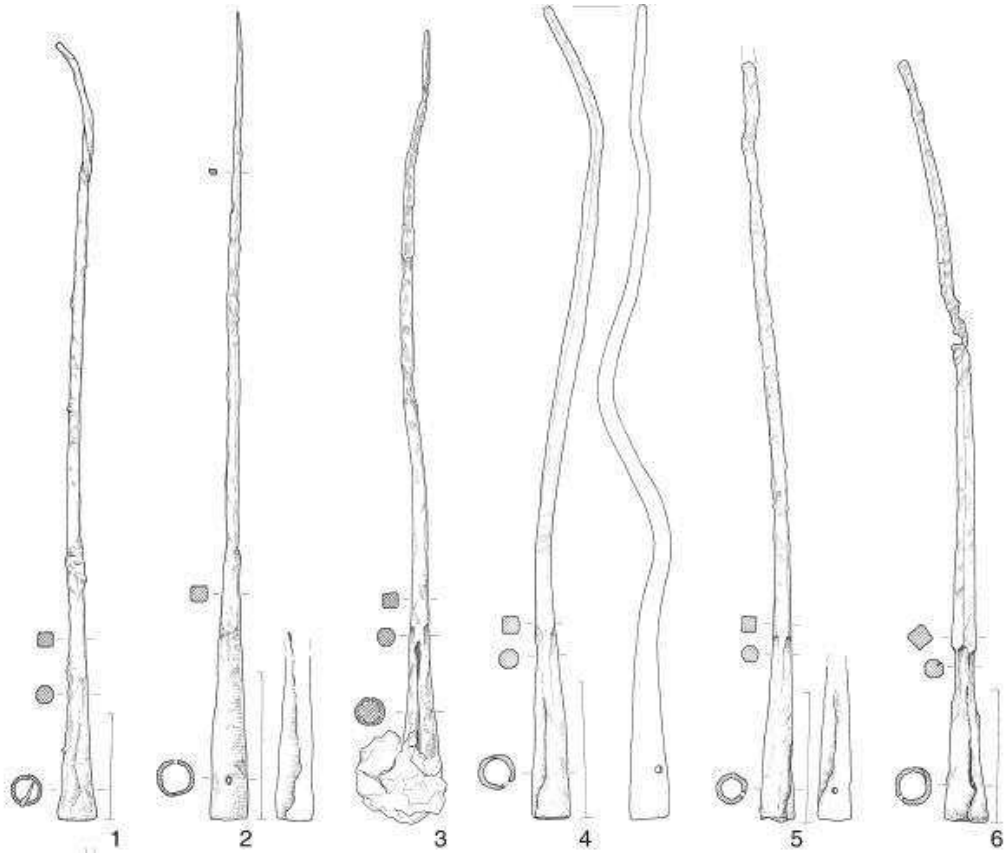

Fig.3. Heads of javelins from Grad.

Source: J. Horvat, The Hoard of Roman Republican Weapons from Grad near Šmihel, "Arheoloski Vestnik", 53, 2002, p. 179

Mentions of ash spears and javelins[19] are found as early as in Homer's account of the Trojan War. Similarly, one of Ovid's poems includes description of dogwood and ash javelins[20]. This seems appropriate in the case of small-sized Roman weapons, because the iron heads, despite their significant length, were relatively light[21]. Using heavy timber was an inexpensive way to achieve the necessary weight and energy of the projectile while maintaining its small size.

It is possible that Ovid was referring to hunting javelins, which were supposed to last longer, but the design principle would be equally suitable for military equipment. Xenophon stated that the shafts of hunting javelins need to be tough, which is why they should be manufactured from dogwood, similarly to combat javelins[22]. He goes on to claim that in the battle of Daskyleion, Persian horsemen were using dogwood javelins.

[19] Hom., *Il*., 22.328.

[20] Ov., *Met*., 7.661.

[21] The average weight of heads found at Šmihel that were identified in the article as those used by *velites,* without any visible signs of breaking (16 pieces in total), is 77 g (and the maximum weight – 128 g).

[22] Xen.,*Hun*.,10.3.

Fig.4. Painting depicting Sabellian warriors from Paestum, Lukania.
Source: P. Connolly, *Greece and Rome At War*, London 2006, p.105.

A large collection of polearm heads uncovered in the swamps of Illerup Adal in Denmark was mounted on shafts made mostly of ash[23]. The oldest weapon items were dated to the year 200 CE. This proves that the weapon remained popular for a long span of years and that it was invariably constructed of the same materials.

Theophrastos compared the hardness of dogwood to that of horn, which supposedly made it perfect for the manufacture of combat javelins[24]. It may seem odd that such a resilient material was chosen for these projectiles, especially since javelins are generally considered single-use weapons as opposed to the spear[25].

As a side note, it is worth mentioning that the shafts discovered in Denmark were not made from specially selected tree branches, but rather cut out from large sections of the trunk with tools – this required specialist workshops, was time-consuming and incurred additional costs. Of course, despite these preferences with regard to the choice of timber there were still exceptions to the rule. The literature of the subject lists examples of weapons made from less resistant materials such as pine[26] or fir, which according to Livius was used by the Saguntines[27] to make javelins. However, in this example Livius might have been referring to heavy javelins and we cannot be certain if the same criteria were used for both types of projectiles. Also, it is likely that by identifying the kind of timber Livius was trying to emphasize the differences between these particular weapons and the ones he was familiar with.

Polybios does not specify if the shafts of Roman javelins were fitted with leather loops but fortunately other authors provide additional information on the matter. According to Cicero, the weapons

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[23] J. Ilkjaer, *Illerup Adal. Czarodziejskie zwierciadło archeologii*, translated by A. Kokowski, Warszawa 2007, p. 44.
[24] Thphr., *Hp.,* 3.12.1-2.
[25] Even disregarding the cost of materials, a javelin runs a high risk of being damaged during training or hunting, which has proven true during my trials with the replicas – 5 javelin shafts broke in the course of several weeks.
[26] Grat., Falisc., *Cyneg*., 130.
[27] Liv., 21.8.10.

used by the *velites* did in fact include such a loop, called *amentum*[28] (*hastae velitibus amentatae*)[29]. Strabon, on the other hand, in his description of Gallic javelins, specifies that they were not thrown with the aid of a loop. This is most probably contrasted with the Roman method of throwing javelins, which did make use of the leather thong[30].

Due to its numerous advantages, this simple and inexpensive invention quickly became popular both in the military as well as civilian circles. Authors as early as Ennius mention javelins with leather loops (*hastis ansantis, concurrunt undique telis*)[31].

These leather thongs were used both by the Etruscans and the peoples living in the south of Italia. Warriors depicted on the paintings found in Sabellian tombs in Paestum (fig. 4) and Noli (4th/3rd century BC) are seen using not only short but also regular, long javelins with the *amentum*. Also the weapons represented on the walls of the aforementioned Etruscan tomb in Tarquinia are most likely fitted with leather loops. Although Polybios does not mention the *amentum* specifically, his description of an engagement between Roman light infantry and Hannibal's Numidians at the Battle of Trebbia[32] indirectly confirms that such attachments were used. This Greek author also brings to our attention one important detail, namely that once the Romans had used up most of their projectiles they were unable to continue the fight, because the remaining ones were unfit for use due to dampness (*notidos*). Most likely, what affected the weapons on that particular day were snowfall and high humidity, as well as the river water level, which according to Polybios was very high on the day of the battle as a result of prior rainfall[33]. During the crossing, the water reached up to the soldiers' chests, which may have caused the weapons to get wet. Unfortunately, Polybios does not specify why exactly they were rendered useless by the damp.

Fig.5. Depicts an Etruscan warrior about to throw a javelin using a leather loop.
Source: British Museum

[28] Greek – *ankyle*.
[29] Cic., *Brut*., 78.27: "like the javelins of the *velites* with the *amentum*".
[30] Strab., *Geog*., 4.4.3.
[31] Macr., *Saturn*., 6.1.16 (the passage, in which Macrobius refers to Ennius).
[32] Plb., 3.73.1.
[33] Plb., 3.72.4.

Fig.6. Boar hunt; the hunter is throwing a javelin with the *amentum* (as evidenced by the grip).
Benevento, Campania, 340-320 BC
Source: British Museum

A solution to this puzzle may be found in Livius's account of the battle of Magnesia[34]. He describes an analogous situation about javelin-throwers from the army of Antiochus III, who had issues with the leather loops of their weapons due to the humidity caused by the morning mist. The passage includes a specific explanation, i.e. that the humidity softened (*emollierat*) the leather straps, making it difficult to use the weapons effectively. In the absence of precise data on how the loops were attached it is hard to specify the impact of moisture on the *amentum*; however, experiments have shown that even with the simplest binding method water has no marked negative effect on the leather thongs.

What, then, could be the cause of the aforementioned problems with wet javelins? The description provided by Livius is somewhat credible, because if a leather loop gets wet (provided that it is bound to the shaft, and not fitted differently) the knots may come slightly loose as the material dries, which may cause the loop to slide along the shaft. However, it does not happen always and this slight malfunction is not severe enough to make the weapon completely ineffective in combat. In the end, it is always possible to refasten the knots. And all of this becomes a moot point if the leather strap is fitted differently than by binding, e.g. with a nail. Finally, if there is no time to make any adjustments, a soldier could simply throw the javelin without using the *amentum*.

It is worth delving deeper into this particular issue, as it leads to additional conclusions. There are many indications that both the Greeks and the peoples of Italy used combat javelins with permanently fixed leather loops. Xenophon writes that during their retreat after the battle of Cunaxa, the Greeks fitted captured large-sized arrows with leather loops and used them as javelins[35]. In a different passage he orders the javelin throwers to ready themselves for immediate action by placing their hands over the leather loops[36]. Also Plutarch, when writing about the wounding of Philopoemen, mentions a javelin with a loop. It was precisely this leather strap, and the fact that it was attached permanently,[37] that made it impossible to remove the projectile from the wound. In addition, there are many iconographic sources

[34] Liv., 37.41.2.
[35] Xen., *Anab*., 4.2.28.
[36] Xen., *Anab*., 5.2.12.
[37] Plu., *Phil.*, 6.4.

depicting javelins with a fixed *amentum*, for example the famous mosaic showing one of the battles fought by Alexander the Great (battle of Issus or Gaugamela), or the already mentioned frescoes from Paestum and Tarquinia. Numerous detailed images and descriptions enable us to reconstruct the throwing method quite accurately. The soldier would hold the javelin with the ring finger, the pinky and the thumb. The middle and index fingers are placed inside the loop which is used to make the throw – *ammentum digitis tende prioribus et totis iaculum derige uiribus*[38], *inserit amento digitos*[39]. Interestingly enough, this specific grip was common among athletes as well as soldiers, both in Greece and in Italia (fig. 5-6). Placing the hand over the leather strap forming the loop is very natural, which is probably the reason for the grip's popularity.

Previous experiments with the *amentum* and its actual potential

The thin and short shafts of Roman military javelins make it considerably difficult to throw the weapon accurately. Using the leather loop makes the grip and the throwing motion more comfortable and also causes the projectile to fly more flat along a greater distance. This effectively increases the thrower's arm length and the time of contact between their hand and the javelin, resulting in increased propulsion force. This, in turn, leads to an increase in the projectile's kinetic energy and, to a large extent, its range and penetration capabilities. Thus, light infantry soldiers were able to engage the enemy from a greater (and therefore safer) distance.

This article is not the first one that studies the effects of using the *amentum*. One of the first scholars who dealt with this subject was H.A. Harris[40]. In 1963 he conducted an experiment to analyze the impact of the *amentum* on javelin range. He had attempted to recreate the throwing techniques used by Greek athletes with the *amentum* not fixed permanently. However, his methodology was deficient, which is why he only noted a range increase of 25% – an unsatisfactory result according to Harris himself. In the years 2010-2011 the subject was once again studied by Steven Ross Murray, a professor of kinesiology at the Colorado Mesa University. He carried out experiments consisting in throwing replicas of a Greek athlete's javelin (*amentum* unattached) and a combat spear fitted with a leather loop (*amentum* attached permanently). In both instances the experiment yielded very promising results. Murray found that by using the *amentum* the javelin range increased by 58%. And the prolonged contact between the hand and the weapon shaft led to a 26% increase in velocity[41] compared to traditional throwing techniques. Similar results were achieved for the spear[42]. The discrepancies between the results of these past experiments

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38 Sen., *Phaed*., 812: "pull the loop tight with the first two fingers, then throw the javelin forward with all your strength".

39 Ov., *Met*., 12.321: "he placed his fingers inside the *amentum*".

40 H.A. Harris, *Greek Javelin Throwing,* "Greece & Rome, Second Series", vol. 10, no. 1, 1963, p. 26-36.

41 S.R. Murray, W.A. Sands, N.A. Keck, D.A. O'Roark, *Efficacy of the Ankyle in Increasing the Distance of the Ancient Greek Javelin Throw*, "Nikephoros", 23, 2010, p. 43-55.

42 S.R. Murray, W.A. Sands, D.A. O'Roark, *Throwing the Ancient Greek Dory: how effective is the attached ankyle at increasing the distance of the throw*, "Palamedes", vol. 6, no. 1, 2011, p. 137-151.

have encouraged me to carry out my own original experiment in order to verify the results and confirm if the same values will be achieved for short Roman combat javelins.

The experiment

In the case of light infantry, attempts to increase the range of weapons have always been a crucial aspect of gaining advantage over the enemy. Of course, it is impossible to determine the capabilities of an average Roman army recruit in terms of range and throwing technique. These were largely determined by the fact that the citizen army was conscription-based. The short term of service and the lack of regular and sufficiently long training before the campaign[43] would undoubtedly affect the level of skill of individual soldiers, particularly since most recruits were unfamiliar with a weapon like the javelin. This was sometimes problematic when the army was facing professional soldiers skilled in such craft. Livius, in his description of a clash between the *velites* and the forces of Philippos V, stated that the king's light infantry was more effective in ranged combat, whereas the Roman soldiers dominated in melee, being better protected by their shields[44].

Despite the lack of data regarding weapon range we may still attempt to determine the capabilities of an ancient javelin thrower. From Polybios's description of a Roman military camp we learn that the distance between the embankment and the tents should be 200 feet (approx. 60 m), which guaranteed relative safety from enemy ranged attacks[45]. He claimed that very few projectiles would be able to reach further. He was most likely referring to attacks carried out by light infantry armed with javelins or possibly stones, because the range of slings or bows far exceeded the given distance[46]. Moreover, if we assume that the weapons were thrown from at least a couple of meters away from the camp embankment, we end up with a respectable range of 60-70 m. The results of my experiment indicate that an experienced javelin thrower using a combat javelin fitted with an *amentum* would be capable of achieving this range. My own record javelin throw with the use of *amentum* is 56.1 m, and when positioned with a faint wind at my back – 60.5 m[47]. According to Harris, athletes participating in the games could throw javelins as far as 300 feet (approx. 90 m). In those perfect conditions and with the use of specially constructed projectiles such a feat could be possible, but nevertheless few people would be able to do it. And we need to bear in mind that the ranges achieved by athletes may differ significantly from those recorded by an average light infantry conscript, even such that had already served through several

[43] Plb., 3.70.3; 3.106.5.
[44] Liv., 44.35.19.
[45] Plb., 6.31.19.
[46] According to Vegetius, recruits were trained in the use of the bow and the sling up to a range of 600 feet (Veg., 2.23.10), but we do not know if this was considered the maximum range or the effective range. For more on the range of ancient bows, see: W. McLeod, *The Range of the Ancient Bow*, „Phoenix", vol. 26, 1, 1972, p. 78-82. After only a couple of tries, using a simple sling with an arm length of 80 cm, the author was able to throw a 60 g stone bullet up to a distance of 120 m. The current record in throwing a 52 g stone bullet, achieved on August 21, 1981 by Larry Bray, is 437.10 m – http://en.wikipedia.org/wiki/Sling_(weapon).
[47] These results were achieved without wearing any encumbering or restricting equipment, such as a shield, helmet or other protective gear.

campaigns. As Harris points out, there were fundamental differences in the design of combat and sports javelins.

Training a proficient javelin thrower was not an easy task. Livius claims that it was no less difficult than training a bowman or slinger (*exceteris navibus sagittarii funditoresque et velites etiam, quorum telum adremittendum inhabile imperitis est*)[48]. It also required the prospective user to have certain predispositions. The credibility of the experiment referred to by Gardiner, which had been conducted by general Reffye at the request of Napoleon III, seems highly questionable. In that study a javelin thrower using the traditional technique was only able to throw to a distance of 20 m, whereas with the *amentum* this range rose to 80 m. The issue with these results is that any person struggling to achieve the first would be completely unable to achieve the second one. In the case of a javelin, the flight distance is not dependent solely on the strength of the user. An equally – if not more – important factor is the throwing technique. The *amentum* would not miraculously make up for deficiencies in any of these two areas.

The impact of *amentum* on weapon range

The experiment was broken down into two stages. The first one was intended to confirm the increase in javelin range when using the leather loop as compared to traditional techniques. The second stage focused on studying the practical and combat characteristics of reconstructed javelin heads and the impact of the *amentum* on the comfort of use. The replicas were modeled after the two javelin heads discovered in Šmihel; these were selected due to differences in their length and thickness, and also because they show no visible signs of breaking. The heads were made from currently available structural steel.

For the tests intended to determine the difference in coverage based on different throwing techniques I've used a javelin prepared according to Polybios's description. Due to the high number of planned test throws, and the resulting high risk of damage to the javelin, the head was made more massive. The overall javelin weight was 495 g and the total length – 115 cm. The weight of the head was 210 g, and the 90-centimeter shaft was made from beech wood (*Fagion sylvaticae*). The replicas were fitted with 25 cm long loops[49] made from a leather strap 6 mm wide and 2.5 mm thick. These were attached permanently using a simple knot.

The trials focused on four throwing techniques, marked A, B, C and D (fig. 7):

A – freehand throw

B – throw using a straight *amentum*

C – throw with the *amentum* wrapped around the shaft

D – throw with an unattached *amentum*

For the three techniques using the *amentum* the tests included both standing throws, as well as throws with a run-up of 4 m. In the case of method D, only tests with a run-up were performed.

[48] Liv., 24.34.5: "from most of these warships by bowmen and slingers, as well as *velites*, whose weapons were difficult to use by inexperienced soldiers".

[49] In the course of numerous trials it was found that for a javelin of the specified size an *amentum* with a length of 20-25 cm provides the best combination of effectiveness and utility.

In the case of all specified techniques the trials consisted of four series of 20 throws. From each series, 15 of the most unambiguous results were selected for statistical calculations. Tests were carried out in windless weather. They were preceded by two-month preparations necessary to determine the length of the *amentum* and suitable throwing techniques, in order to achieve the best possible results. During trials, javelins were thrown using all techniques in an alternating pattern, starting with the freehand throw (method A) and changing after each throw. This made it possible to ensure similar physical and weather conditions for each series. The same criteria were used both for standing throws and run-up throws.

Technique A was used as the reference point for remaining techniques, which allowed me to evaluate the effectiveness of the *amentum*. As could be expected, after preliminary throws, the results achieved using method A were the lowest. For all series of standing throws the average distance was 31.7 ± 1.3 m, and the maximum distance – 34.4 m. When using the *amentum*, the average result for technique

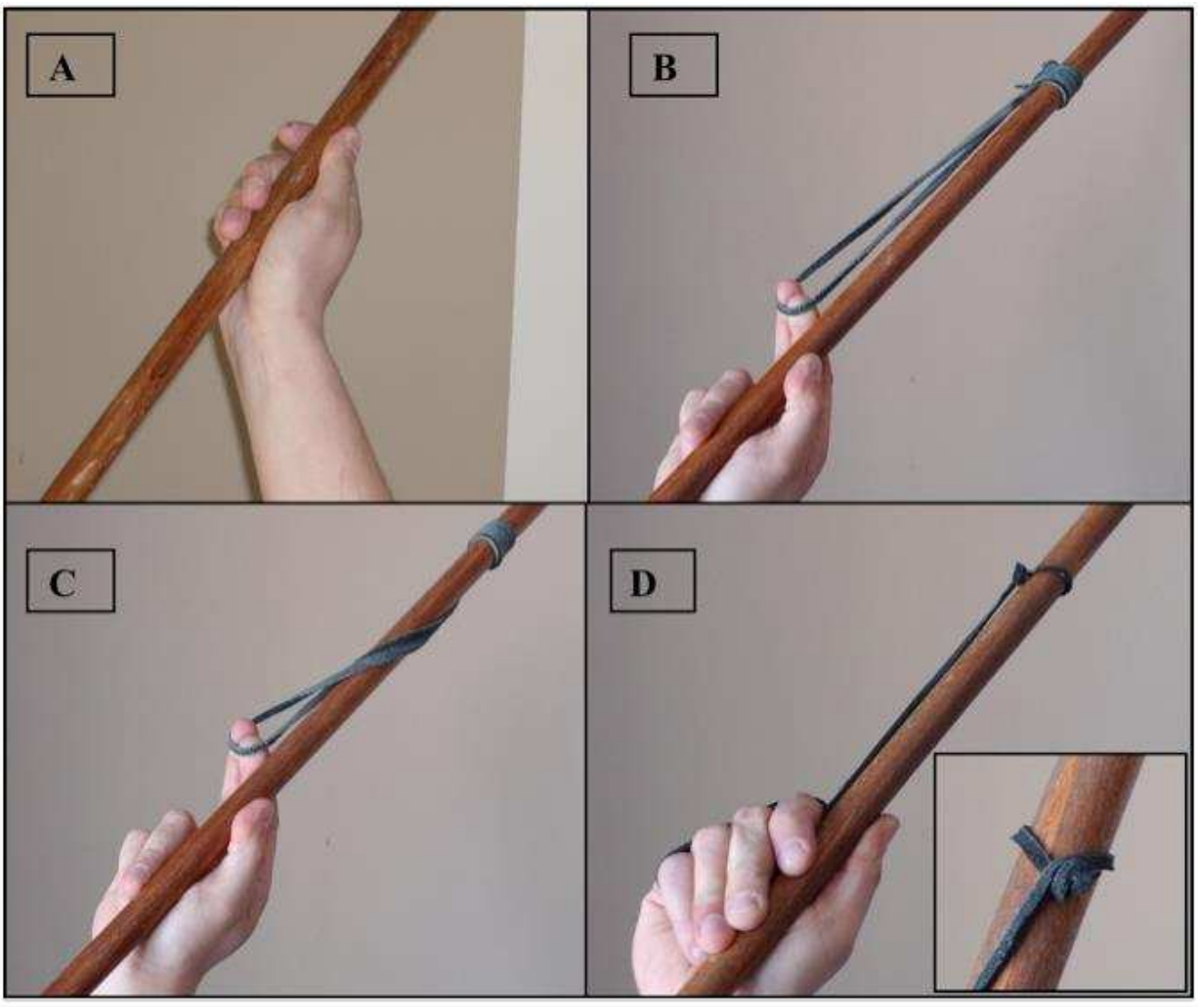

Fig.7. Grips used for each of the specified throwing methods.
Photo by the author

C was 45.75 ± 1.25 m (with a maximum distance of 44.7 m), and for technique B the average range rose to 49.22 ± 1.3 m, i.e. by 55.28% (maximum distance – 51.6 m). The results were similar for series of throws performed with the run-up. The range increase was comparable[50]. The average distance achieved for technique A with a run-up was 35.54 ± 0.83 m (with the maximum distance being 37.16 m). The results for method C were, on average, 50.82 ± 0.94 m, i.e. an increase of 42.98% (with a maximum distance of 53 m), and for method B – 53.83 ± 1.23, which corresponds to a range increase of 51.45% (the maximum distance achieved was 56.1 m).

The javelins used by light infantry were smaller than those used by their heavily-armed counterparts. Specifically, the smaller javelin differs in terms of thickness – the shaft is much thinner, which negatively impacts the comfort of the grip and thus affects the thrower's effectiveness. Holding the javelin during a throw puts significant strain on the arm. The leather loop allows for a much more natural movement, because the javelin is only supported by the hand in the initial stage of the throw. In the later stages it is propelled by the two straightened fingers pulling the loop (fig. 8), contrary to the traditional throwing method, in which the hand touches the shaft throughout the whole movement. Consequently, achieving a similar distance is possible while putting much less force behind the throw.

But the greatest advantage of the *amentum* comes from the increased range. This was proven by the results achieved with techniques incorporating an attached leather loop. As we've seen, the improvement in range provided by the *amentum* is evident for both these throwing methods. The difference between the two is probably due to the loss of a portion of kinetic energy, which in the case of method C sets the javelin in a spinning motion.

But this is just one of the factors that affect the range. The leather strap cannot be wrapped too many times around the shaft, as this prevents it from unwrapping completely during the throw – it does so during flight. As such, the effective length of the loop is reduced and its potential is not fully utilized. For the loop length specified herein, the best results were achieved with the *amentum* wrapped once over a long section of the shaft (fig. 7, C). Wrapping it multiple times, like a spring, moves the place of the grip away from the center of mass and, as has already been described, has a negative impact on weapon range. The *amentum* should be so long as to allow the shaft to be gripped around the javelin's center of mass, and at the same time short enough to fully utilize its potential. Increasing the length of the leather loop beyond a certain point – in the case of both techniques – does not provide any meaningful increase in range and only becomes more problematic.

In the case of method C, the leather strap unwraps during flight and, as a result of centrifugal force, positions itself perpendicular to the shaft. If its length – and, consequently, unevenly distributed mass – is too high, it often puts the rear of the javelin in a disadvantageous circular motion. This, combined with the drag caused by the leather strap, is one of the reasons for achieving lower distances

[50] It is surprising that for series A, B and C, the difference between the range of standing throws and run-up throws was, respectively, 12.1%, 11% and 9.36%, which seems quite small.

Fig.8. Movement sequence for throwing a javelin with the *amentum*. We can clearly observe how the leather loop lengthens the thrower's arm, increasing the propelling force.
Photo by the author

with technique C as compared to B[51]. The motion stabilizes in the final stages of flight along with the decrease in javelin rotation velocity.

Similarly, when using throwing method B, a longer leather loop causes numerous problems for an inexperienced user. In the initial stage of the throw it often causes the head to tilt upwards, which in many cases leads to the javelin dropping to the ground shaft-down, or flipping end over end, resulting in a failed throw. But, provided that a few basic principles are followed, this technique does offer a number of advantages. First of all, we are utilizing the whole length of the loop, which translates directly into better results. During flight the loop positions itself along the shaft, producing no significant drag, and the javelin remains almost perfectly stabilized throughout the whole movement. Many authors emphasize the need to set the javelin in a spinning motion, similar to a rifle bullet, in order to improve the weapon's stability in flight[52]. But oftentimes achieving the spinning motion is simply the result of using a specific throwing method. The javelin's design differs radically from that of a bullet and as such the weapon does not require the same measures to ensure accuracy. Actually, a permanently attached leather loop helps stabilize the javelin, serving a function similar to that of an arrow fletching, which ensures that the javelin hits the target point-down. The results of throws made using technique B fully confirm these observations. As was already mentioned, provided that basic principles are followed, both method B and C ensure similar javelin flight stability and accuracy. Wrapping the leather strap around the shaft may be valid when throwing on smaller distances – not exceeding 20 meters. In the case of technique B the javelin shows stronger tendencies to tilt upward in the initial stage of flight, which results in the weapon arcing higher than intended. This phenomenon becomes even more common with the increase in loop length. With regard to this particular aspect, using method C yields better results and reduces the risk of arcing higher, due to the javelin's spinning motion and the fact that the hand remains close to the javelin's longitudinal axis longer. It is also possible that these differences are the result of the author's lack of experience.

[51] Another reason for the phenomenon in question is the small length of the javelin shaft.
[52] Setting the javelin in a spinning motion may be more valid when using a throwing technique utilized by ancient athletes, in which the *amentum* remains in the thrower's hand or detaches from the javelin in the initial phase of flight (Murray, Sands, Keck, O'Roark, *Efficacy…*, p. 43-55).

Nevertheless, in both instances the user's comfort during the throw and the weapon's stability are much higher than in the case of the regular freehand method. When the basic technique is used on short distances such a short javelin tends to tilt in the initial stage of flight and often hits the target at a low angle, which reduces its penetration capabilities.

As we've already seen, the *amentum* allows us to throw the javelin in several different ways. The methods described above are not comprehensive. It is entirely possible that an experienced javelin thrower would use more than one throwing technique depending on the situation[53], particularly that it would not require any changes to the construction of the *amentum*. Using the leather loop for long-distance throws, where accuracy is of no importance, poses no problems for an averagely athletic person after only a short training period[54]. However, trying to hit a specific target, even on short distances, requires many hours of training. Each individual must use trial and error to learn the correct method of throwing. All it takes is for the user to place the fingers too deep within the loop and the result is a prolonged leading motion (i.e. fingers staying within the loop for too long during throw), which tilts the javelin head up and changes its trajectory into a high arc, thus significantly limiting the range or resulting in a completely failed throw. A similar thing occurs if we place the fingers not deep enough. Then, during the leading motion, the leather loop slips off the fingers and we are unable to transfer the full force of the arm onto the javelin, which also reduces the distance of the throw and often even changes the javelin's flight path. One of the most important things to remember when using the *amentum* is to ensure that the leather loop is pulled in as tight as possible; anything less will result in reduced range and higher risk of a failed throw.

There are also ways of throwing the javelin with the use of the leather strap, so that it remains in hand[55] (fig. 7, D) or falls off the javelin after the throw. In the first case the leather strap is not attached as a loop and needs to be held in place by hand or, for example, wrapped around the wrist. This method yielded results comparable to those achieved with method C. The average range was 50.43 ± 1.01 m, corresponding to an increase of 41.89% compared to the traditional technique (the maximum distance achieved was 52.43 m). This is probably the simplest way to attach the leather strap and wrapping it once ensures a surprisingly strong grip. The simplicity of this solution is its greatest strength. A knot at the end of the leather strap blocks the strap in place, preventing it from sliding down along the shaft.

In order to test whether this method was affected by javelin length and, consequently, mass, I've conducted trials with shafts of differing lengths – 180 cm, 150 cm, 110 cm and 90 cm. When thrown, the javelin is set in a spinning motion, which is not deliberate but is rather a side effect of the binding method used. Regardless of length, the javelin remained stable throughout the whole flight and always hit the ground point down. The results of short-distance throws were similarly positive. One thing to remember

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[53] Flor., *Epit.*, 1.43.8.5 – similar to Balearic slingers, who equipped themselves with 3 types of slings of different lengths.

[54] The issue is not the general fitness of a given person, but rather their manual skills, which can be developed by doing certain types of sports (this was proven true by my own experiences and studies conducted by Dr. S.R. Murray).

[55] E. Gardiner, *Throwing the javelin,* "The Journal of Hellenic Studies", vol. 27, 1907, p. 249-273.

is that the leather strap cannot be attached too close to the shaft's end as that can negatively impact the weapon's stability during flight. During testing, for the 90-cm shaft I've used a loop approximately 20 cm in length[56]. Similarly to technique B and C, the weapon should be gripped around the center of mass. It is a very comfortable technique, allowing the thrower to reuse the same leather loop over and over again, and preventing the enemy from achieving the same distance with the collected weapon – assuming, of course, that the enemy does not possess a leather loop of his own.

However, if the leather strap is wrapped twice around the shaft, there is a sudden drop in effectiveness. In this configuration the results are more dependent on the shaft length and mass. The spinning motion achieved during throw is so strong that any javelin shorter than 150 cm starts to swing and falls side-first – this occurs more often the shorter the javelin is. During my 25 attempts with a shaft length of 90 cm, only one throw ended with the javelin hitting the ground point-down. The throwing range was comparable, and sometimes even shorter, than that achieved using the traditional technique (A). Also, with this method it is more problematic to prepare the weapon for use – the actions are time-consuming, involve both hands and make it difficult to hold additional projectiles in the left hand.

In the second case, i.e. using the binding method that had been problematic for Harris but was later perfected by Murray, the leather strap is wrapped several times over the shaft, and a loop is formed at the end of the strap using a simple knot. The fingers are placed inside the loop. In this case, the *amentum* falls off shortly after the weapon has been thrown. By using this method, Murray was able to achieve a range increase of 58% compared to the traditional technique[57]; the tests were carried out without a run-up.

Head deformation issue

Tests carried out with reconstructed javelins have confirmed the words of Polybios: even in the case of a weak throw, with the weapon flying less than 20 meters and hitting a sandy ground, the head deforms so that the javelin is unfit for immediate reuse (fig. 9). The severity of deformation increases with the increase in distance and throw strength.

Fig. 9. Javelin heads damaged after throw and a single head removed from an obstacle imitating a shield. Photo by the author

[56] The length of the leather strap is measured from the binding to the grip.

[57] The large differences of the results achieved by beginners compared to the traditional technique may stem from their lack of experience in javelin throwing (the average results for the traditional technique did not exceed 20 m, and with the use of the *amentum* – 31 m). Despite my experience in throwing a sports javelin and my significantly longer preparations, I've been unable to exceed the distances listed by Dr. Murray. It seems that with an increase of skill in using the traditional technique, the difference between the results achieved by the two techniques becomes less pronounced.

A similar thing occurs when throwing straight into a hard obstacle, particularly over small distances. Because such a short javelin is very susceptible to deviations during flight (for distances shorter than 15 m), the head often gets strongly bent after hitting its mark. This occurs particularly if the obstacle in question is unstable, like in the case of a shield held in hand. Attempting to retrieve a javelin stuck in the target leads to further bending of the head. In all such cases the severity of deformation depends on the head length and thickness. However, this damage is not irreparable. The majority of bent javelins, especially those that hit the ground, were made ready for reuse in a matter of minutes either by hand or by using two small stones – a method that seems to have been mentioned by Lucanus: *tunc omnis lancea saxo erigitur*[58]. This passage describing preparations before the battle in Pompey's camp illustrates the importance of being able to quickly repair one's equipment without having to visit the camp workshop.

Tested javelin heads tended to deform in the same places during consecutive throws. Repeated bending causes localized weakening of the metal and may lead to fracturing. A large portion of heads discovered in Šmihel shows signs of fracture. Most certainly, the quality and the method of working the iron used to manufacture these weapons varied, depending on the skills of the blacksmiths and how much time they had. Elements that were too inflexible, and therefore more fragile, would suffer from wear significantly faster. But the repair potential of these javelin heads seems quite high. It is likely that even broken ones were still sharpened to a point and reused, which would pose no problems due to their length, or that broken-off fragments were reattached in various ways, e.g. with wire[59]. In the case of a leaf-shaped javelin head, any damaged pieces would have to be re-forged into a new javelin head.

Penetration capabilities

Despite their apparent fragility, the javelin heads in question demonstrate very good penetration characteristics against a range of covers. Their length and small diameter make them particularly effective against enemies clad in chainmail or flexible armor made of natural materials – the long javelin head has a higher chance of reaching a vital organ and causing serious injuries. On the other hand, the tested pieces have proven equally effective at bypassing hard means of protection, such as shields or breastplates. Penetration tests with both these items were carried out from a distance of 15 and 25 m without the use of *amentum*.

The target imitating a shield was made from three layers of oak strips placed vertically and horizontally in an alternating fashion, with a total thickness of 12 mm, according to the design of the shield found in Kasr-el-Harit[60]. The model of an Italian breastplate was made from 0.8 mm thick bronze sheet (fig. 10). For the tests I've used two javelins with long heads, marked A (longer) and B (fig. 11), and – for comparison – one with a leaf-shaped head, marked C (fig. 12). The collected data is presented in the form of a table (tab. 1). Shields made from only a single layer of wood, not additionally covered with canvas or leather, are penetrated much more easily due to the splitting of the material. It is entirely possible for a javelin to strike at a target hidden behind such cover.

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[58] Luc., *Civ*., (*Pharsalia*) 7.140 – "they straighten their javelins using stones".

[59] Horvat, op. cit., p. 179.

[60] P. Connolly, *Greece and Rome at War*, London 2006, p. 132.

A quick analysis of the results makes it clear that javelin heads A and B have a distinct advantage on both distances and against both targets. In the case of the breastplate the penetration capabilities of type A and B heads were several times higher than for type C. Trials with a mock shield have yielded similar results – when comparing the results achieved with either type A or B to the leaf-shaped javelin head, there was a multifold difference in penetration strength stemming from their specific design. When analyzing these results we need to bear in mind that the penetration characteristics are dependent on numerous factors,

Fig. 10. A bronze plate imitating an Italian breastplate.
Photo by the author

such as the head shape, the quality of the iron that it was made from, the hit location, and the angle, at which the target was struck. The thrower's skill is equally important. Because there are so many variables, the test results should be treated provisionally, but they still offer a certain insight into the difference between the effectiveness of the two javelin head types. As has been demonstrated, any wound inflicted with type A head, in the case of a clean hit, would have been very deep even despite the protection offered by the breastplate, and could thus either kill or eliminate the enemy from the fight. Also, had the breastplate been thicker or the distance greater, the leaf-shaped head could prove completely useless. But we need to bear in mind that when using the *amentum* there is a significant increase in the javelin's velocity and kinetic energy, which highly improves its penetration characteristics. One series of throws at a polystyrene block with a type-B head has demonstrated that the increase in penetration with the use of *amentum* is over 30%.

One interesting detail is how problematic it was to remove A and B type javelins from the shield. The whole process was very difficult and required discarding the shield to the ground and bracing oneself against it with the legs. Naturally, attempting to remove the javelin simply by performing swinging motions with the shield only led to further deformation of the head. This shows that in a combat situation removing such projectiles would be difficult, if not impossible, without depriving oneself of protection offered by the shield. In contrast, removing a leaf-shaped javelin head, which is much less flexible, poses no such problems. All it takes is performing several swinging motions with no need to discard the shield; also, in this case the risk of damaging the head is much lower.

Fig.11. Javelin heads A and B

Photo by author

Fig.12. Javelin head C

Photo by author

	Throwing distance (m)	Penetration of breastplate (mm)					
Grid A	15	114	110	90	81	61	59
	25	59	55	49			
Grid B	15	89	78	71	69	58	47
	25	70	43	39			
Grid C	15	41	30	16	11	16	8
	25	23	19	17			
		Penetration of the model of shield (mm)					
Grid A	15	79	78	68	65	59	54
	25	76	66	59			
Grid C	15	20	19	19	16	14	12
	25	15	15	09			

Tab.1. Data of penetration capability hard means of protection

The impact of humidity on the *amentum*

The results of my tests studying the impact of water on the structure and usability of a javelin with the *amentum* have been inconclusive[61]. Trials carried out in December, in rainy weather at 4°C, and in snowy weather at 0°C (the Battle of Trebbia was likely fought in similar conditions) have shown no significant changes in the comfort of use, with the exception of the weather's impact on the human body[62].

Conclusions

It might seem that compared to the development of weapons employed by heavy infantry, the ones used by light formations remained stagnant. However, the equipment of light infantry, especially offensive weaponry, underwent constant changes, which can be clearly seen on the example of the Roman javelin.

Tests have proven their high effectiveness and versatility. The deliberate design of javelin heads provides high penetration ability, greatly exceeding that of leaf-shaped heads, and the simple construction ensures good repair potential, so crucial during lengthy campaigns. The use of the leather loop allowed for an increase in range of over 50% after a relatively short training period and did not present any challenge even for beginner users, which confirms the findings of other authors. However, some issues require further study, like for example the increase or decrease in accuracy on short distances with the use of *amentum*, the amount of training necessary to achieve accuracy comparable to that of the traditional technique, or how many soldiers could actually reach the level of skill that allowed them to be effective in battle. Whereas issues related to training affect all javelin users to a similar extent, regardless of place, the unique design and characteristics of the weapon used by Roman light infantry have allowed the *velites* to maintain a slight advantage over their enemies in that timeless arms race that is war.

[61] After soaking the javelin with the leather loop in water for several hours, the only significant change was an increase in weight of around 16%. Instead of loosening, the water actually tightens the knots on the leather strap (probably due to swelling of the material), which additionally prevents the loop from sliding along the shaft. As regards the mass increase, similar differences in weight occur when using different kinds of timber, which makes it a marginal issue. Also, I've noted no visible drop in weapon range or comfort of use, especially none that would make the javelin unfit for use with any of the throwing techniques described herein.

[62] According to Polybios, the battle took place on a cold and snowy December day, preceded by rainfall on the previous night, which caused the river water level to rise.

Javelin replicas

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